Building Cybersecurity Mindset through Continuous Cross-module Learning

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Motivation & Goal

- The remarkable projected growth rate of cybersecurity positions indicates the strong demand for cybersecurity professionals.
- Filling such a workforce demand is not only preparing dedicated cybersecurity students. More importantly, it is essential to establish a **cybersecurity mindset** for computer science students in general, because they will contribute to the majority of the cybersecurity-related workforce in the near future.
- Aims to promote cybersecurity education for undergraduate computer science students in general and prepare a future cybersecurity workforce.
- Instead of heavily relying on dedicated cybersecurity courses in most existing undergraduate cybersecurity education, this project proposes the concept of **cross-module learning** that leverages non-cybersecurity computer science courses at different levels to continuously instill security concepts and skills to train students from the early stage of undergraduate learning.

Research Questions

- This project aims to answer the following questions:
- How can non-cybersecurity computer science courses be optimally utilized to consistently imbue security concepts and skills in undergraduate students from the early stage of their studies?
- What strategies can be employed to mitigate disruptions to existing computer science curricula when integrating cybersecurity modules?
- In what ways can cybersecurity modules enrich students' comprehension of non-cybersecurity computer science courses, fostering a more holistic understanding of computer science knowledge?

Project Outcomes

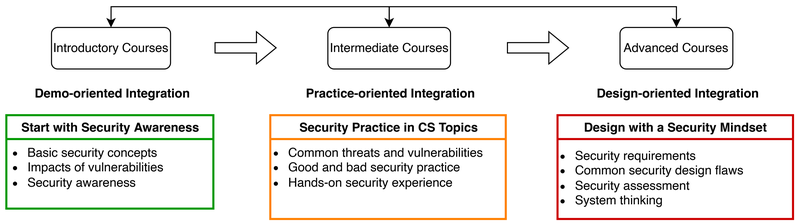
- The cross-module learning concept for cybersecurity mindset preparation with a mapping of appropriate computer science courses and cybersecurity modules for integration, effective integration strategies, and potential linkages among different courses and modules.
- Cybersecurity modules with curriculum materials using threat-driven approach.
- A transferable laboratory framework with hands-on cybersecurity exercises for non-cybersecurity courses to support cross-module learning. The proposed framework utilizes the "build it, break it, and fix it" concept to support cross-module learning, i.e., building applications based on the non-cybersecurity course's content, breaking them by discovering and exploiting vulnerabilities and then fixing them with security practice and designs of countermeasure.

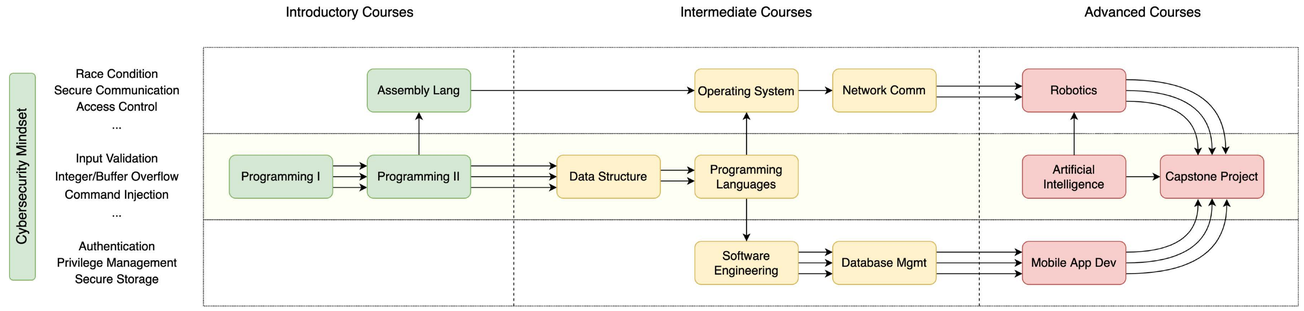
Broader Impacts

- This project will directly expedite cybersecurity education for about 1,300 undergraduate students at UMass Dartmouth and CSU San Marcos, an HSI, by (1) preparing their cybersecurity mindset through continuous integration even without taking dedicated cybersecurity courses and (2) motivating their interest and study in cybersecurity.
- The CSIS Department of CSUSM has over 43% of students from historically underrepresented minority groups. This project will not only benefit the minority students at CSUSM, but also the minority students at the nearby community colleges who have established 2+2 programs with CSUSM.
- The modularization design of curriculum materials and easy-deployment laboratory framework will also facilitate the transfer and adoption of outcomes from this project in other institutions. Outcomes from this project can be leveraged by educators, researchers, and professionals from different institutions for further development to promote the sustainable contribution and improvement of cybersecurity educational materials for the community.

Project Progress & Results

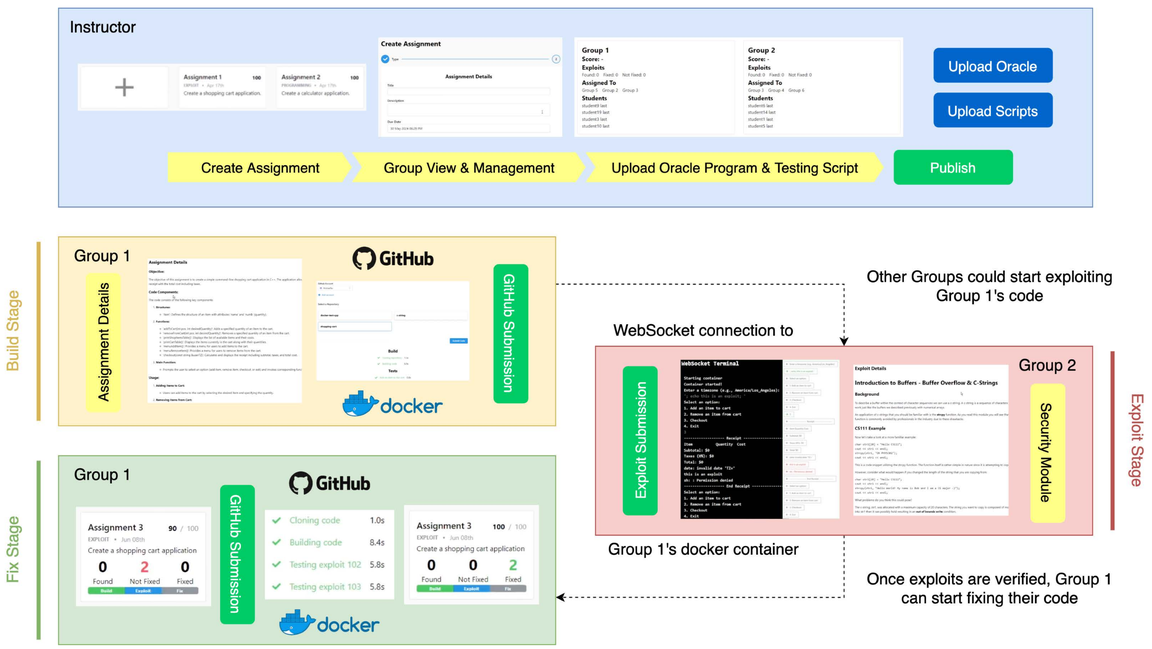
- Project has involved 2 students from UMass Dartmouth and 3 students from CSU San Marcos.
- Project team has identified a series of non-cybersecurity computer science courses that could be integrated with cybersecurity concepts and practice modules.
- Project team has identified effective integration strategies to integrate the security modules into computer science courses at different levels. Specifically, a demo-oriented integration will be adopted for introductory courses to help students form security awareness. For intermediate and advanced courses, practice- and design-oriented integration will be adopted to help students improve their security mindset via hands-on practice and solution design.

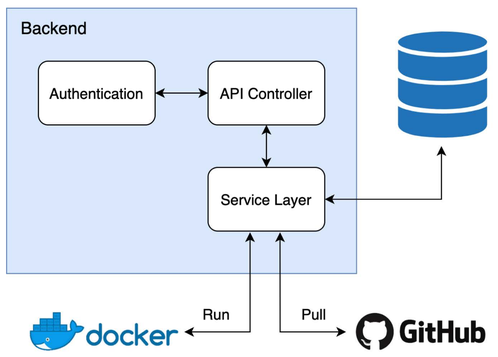




- The project team has identified the module course linkage for continuous cross-module learning, where security concepts will be first introduced in lower division courses and reinforced via multiple upper division courses.
- The project team is working on the cybersecurity module development that can be effectively integrated into existing non-cybersecurity computer science courses.

Project Laboratory Framework





- The proposed laboratory framework has an intuitive frontend that supports both instructors and students, and a modularized backend that allows code pulling from GitHub and code running in docker containers.
- The lab platform supports code functionality testing in build it stage, exploit identification and submission in exploit it stage, and auto security testing in fix it stage. The platform also facilitates team collaborations.
- The lab platform provides detailed analytics data.

Project Intellectual Merit

- This project explores new learning strategies and materials to promote undergraduate cybersecurity education in computer science. The technical merit of this project includes the identification of new learning strategies and the design of new materials.
- The scientific merit of this project lies in the proposed creative concept of cross-module learning that leverages the non-cybersecurity courses for the continuous development of students' cybersecurity mindset.

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